

WHAT IS CLAIMED IS:

1 1. A medium bearing a deformable model configured to
2 enable a machine to estimate positions of four points defined
3 by X and Y coordinates, each of the points representing a
4 facial element position in a digital image.

1 2. The medium bearing a deformable model of claim 1 in
2 which the four points include a first point designating a
3 center of a left eye.

1 3. The medium bearing a deformable model of claim 2 in
2 which the four points further include a second point
3 designating a center of a right eye.

1 4. The medium bearing a deformable model of claim 3 in
2 which the four points further include a third point
3 designating a left corner of the mouth.

1 5. The medium bearing a deformable model of claim 4 in
2 which the four points further include a fourth point
3 designating a right corner of a mouth.

1 6. The medium bearing a deformable model of claim 5
2 further comprising a variable representing a distance between
3 the first and second points.

1 7. The medium bearing a deformable model of claim 6
2 further comprising a variable representing a distance between
3 the third and the fourth points.

1 8. The medium bearing a deformable model of claim 7
2 further comprising a variable representing a distance between
3 eyes and mouth.

1 9. A method comprising:
2 estimating deformable models including eye positions and
3 mouth positions on each frame of a digital image sequence.

1 10. The method of claim 9 in which estimating comprises
2 matching a current face deformable model with image features.

1 11. The method of claim 10 in which the eye positions and
2 the mouth positions are represented by four points defined by
3 X and Y coordinates.

1 12. The method of claim 11 in which the four points
2 comprise a first point designating a left eye center and
3 represented by $i = 1$.

1 13. The method of claim 12 in which the four points
2 further comprise a second point designating a right eye center
3 and represented by $i = 2$.

1 14. The method of claim 13 in which the four points
2 further comprise a third point designating a left mouth corner
3 and represented by $i = 3$.

1 15. The method of claim 14 in which the four points
2 further comprise a fourth point designating a right mouth
3 corner and represented by $i = 4$.

1 16. The method of claim 10 in which the four points of
2 the current face deformable model are determined by six
3 parameters and a base face model.

1 17. The method of claim 16 in which the six parameters
2 comprise:

3 a first parameter representing a distance increase
4 between eyes;

5 a second parameter representing a distance increase
6 between eyes and mouth;

7 a third parameter representing a distance increase
8 between mouth corners;

9 a fourth parameter representing a rotation angle;

10 a fifth parameter representing a shift value along an X
11 axis; and
12 a sixth parameter representing a shift value along a Y
13 axis.

1 18. A computer program product, tangibly embodied in an
2 information carrier, for defining a deformable model for
3 facial recognition, the computer program product being
4 operable to cause data processing apparatus to:
5 estimate base deformable models including eye positions
6 and mouth positions on each frame of a video sequence.

1 19. The product of claim 18 in which estimate comprises
2 comparing a current face deformable model with a previous face
3 deformable model.

1 20. The product of claim 19 in which eye corner positions
2 and mouth corner positions are represented by four points
3 defined by X and Y coordinates.

1 21. The product of claim 20 in which the four points
2 comprise a first point designating a left eye corner and
3 represented by $i = 1$.

1 22. The product of claim 21 in which the four points
2 further comprise a second point designating a right eye corner
3 and represented by $i = 2$.

1 23. The product of claim 22 in which the four points
2 further comprise a third point designating a left mouth corner
3 and represented by $i = 3$.

1 24. The product of claim 23 in which the four points
2 further comprise a fourth point designating a right mouth
3 corner and represented by $i = 4$.

1 25. The product of claim 20 in which the four points of
2 the current face deformable model are determined by six
3 parameters.

1 26. The product of claim 25 in which the six parameters
2 comprise:

3 a first parameter representing a distance increase
4 between eyes;

5 a second parameter representing a distance increase
6 between eyes and mouth;

7 a third parameter representing a distance increase
8 between mouth corners;

9 a fourth parameter representing a rotation angle;

10 a fifth parameter representing a shift value along an X
11 axis; and

12 a sixth parameter representing a shift value along a Y
13 axis.

1 27. A method comprising:

2 receiving a first digital image in a sequence of
3 digital images and eye and mouth coordinates;

4 outputting eye and mouth coordinates on a subsequent
5 digital image in the sequence of digital images.

1 28. The method of claim 27 in which receiving further
2 comprises estimating a base face model and the base face
3 model's transformation parameters T' by the eye and mouth
4 coordinates.

1 29. The method of claim 28 in which outputting
2 comprises:

3 calculating an initial model M as a transformed base
4 model M_b using transformation parameters T' ;

5 rotating the subsequent image to $I(x,y)$ to generate a
6 normalized model M .

- 1 30. The method of claim 29 in which outputting further
2 comprises:
3 calculating a horizontal and vertical gradient map on the
4 rotated image; and
5 estimating new transformation parameters T^* by minimizing
6 an energy function $E(T, I(x, y))$, where $T^* = \arg \min_T$
7 $E(T, I(x, y))$.
- 1 31. The method of claim 30 in which minimizing comprises
2 a downhill simplex method with initial transformation
3 parameters $T = T'$.
- 1 32. The method of claim 30 further comprising
2 calculating the eye centers and the mouth corners by the
3 transformed base model using the transformation parameters T^* .